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Control of Conductivity of Network Path for Neuron-like Conducting Polymer Device

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1. Introduction

Conducting polymers grow with fractal patterns under some polymerization conditions. If the conditions are controlled, neuron-like conducting polymers are synthesized. Furthermore these polymers are connected each other by the change of polymerization conditions during the growing process, or more many conducting polymers are mutually connected and makes a network, which look like neuron. It is known that characteristics of the conducting polymer, optical and electrical one etc, change drastically by doping and undoping. In addition, conducting polymer has characteristics of gel. If the conductivity of the path in the conducting polymer network change with the amount of the electric charge that flows in the path, neuron-like conducting polymer device is proposed. This device has both with both characteristics of function and form. The form depends on environmental condition of the circumference. The function of the device is equal to the conventional neuron device. Learning effects (or memory effect) and nonlinear characteristic are necessary for the path. Recently the function of the neuron is biologically studied in detail. In the field of the information processing the modeling on the work of the neuron also advances. However the following are not carried out using other materials: Function and development of the element with the form of the neuron.

2. Control method in the path between neuron-like conducting polymer networks

2.1 Method using the third electrode.

In order to realize the learning effect dopant quantity in the path should be controlled in proportion to the passage pulses, because the conductivity of the conducting polymer depends on the amount of dopant. The input pulse is divided into two: One is input, and another is sent to the third electrode on the path division. The latter pulse undopes the path under the third electrode. This method works in simple networks. However in the case of the complicated network this method becomes impossible, because it is difficult that the third electrode is placed on every path between the network. Though the method using the third electrode can applies the potential for doping or undoping, the number of the third electrode increases as the network becomes complicated. In order to design the neuron device, this method is not useful.

2.2 The method for not using the third electrode.

The conducting polymer gel swells in the good solvent, and it contracts in the poor solvent. The dopant also goes in and out with this process. By utilizing this property, the method for controlling the dopant in the path is considered. Generally it is easy for conducting polymer to be doped and undoped in the solvent. However if the dopants are kept in the conducting polymer on which certain pre-processing is carried out, this pre-processing is useful for the learning effect. High frequency voltage is applied to conducting polymer as this pre-processing.

3. Experimental

Poly (3-alkylthiophene) is used for gel material. Not network but film conducting polymer is used in order to examine the retention of the dopant in the solvent because it is difficulty to polymerized the network conducting polymer with the same size paths. The polymerization solution consisted of 3- alkylthiophene, LiBF4, and benzonitrile, and the degree of the gel was controlled by the polymerization conditions.

The process of the pre-processing as learning effect follows. The conducting polymer film was divided into two. One is applied at DC voltage and another is applied at AC voltage or AC+DC voltage of 5V and 10kHz in chloroform and iodine. After drying the film, the ethanol was dropped on it.

4. Results and Discussion

At first it was examined that poly (3-alkylthiophene) can be polymerized with fractal pattern and that these are connected each other as well as polypyrrole. Figure 1 shows the growing process of two poly (3-alkylthiophene)s with fractal pattern and the connection of them. The branches grew in and on the solution and then were connected in the solution. For polypyrrole it is easy to handle it because the branches grow on the surface of the bottom cell. In case to make the neuron-like conducting polymer device the connection place should be considered.

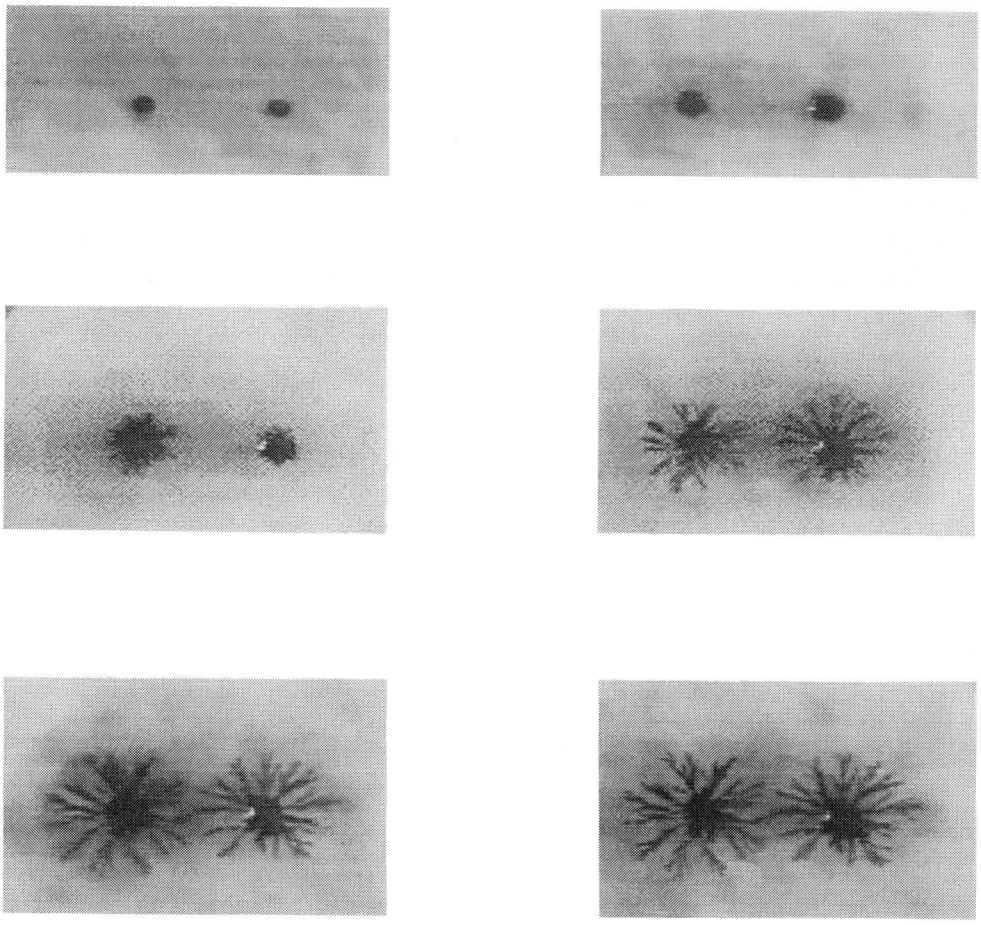

Figure 1. Growing process and connection of neuron-like conducting polymer

The electroconductive polymer connected was soaked in chloroform or ethanol, and the state of swelling or contraction was confirmed. Figure 2 shows both states of connected conducting polymer. Though it is seems like one branching conducting polymer, the big branching at the right side is another conducting polymer. It was confirmed that the network conducting polymer could make.

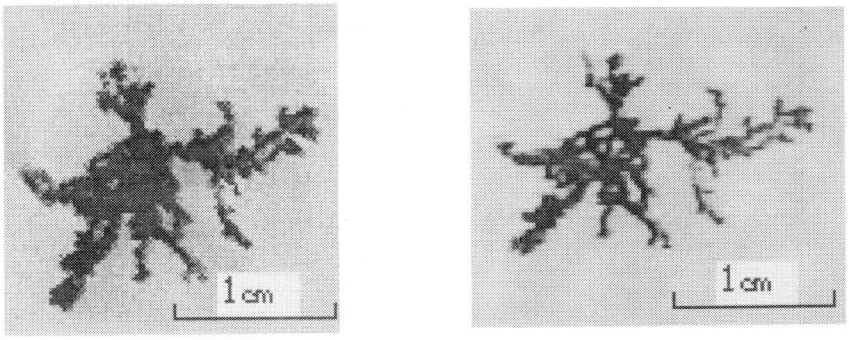

Figure 2. Connected Conducting polymer at both sates of swelling and construction

After pre-processing, the ethanol was dropped on them. Figure 3 show the current of both films after dropping the ethanol. The current for the film applied at AC decreased more slowly than the film at DC. The dopant of the former retained higher than the latter.

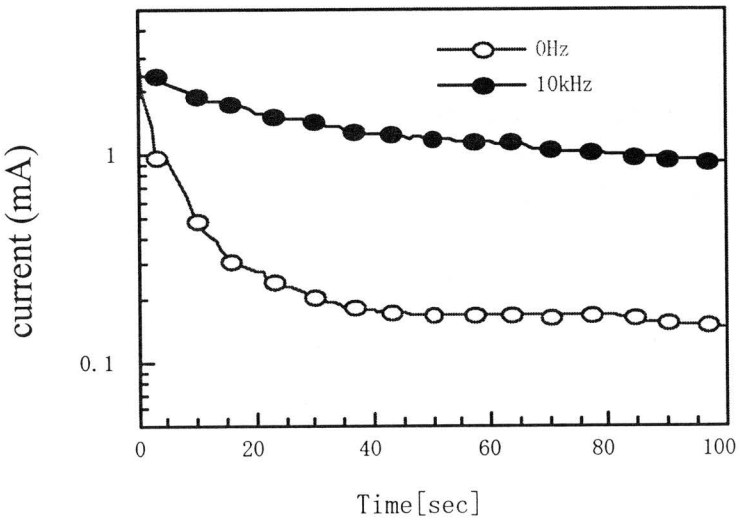

Figure 3. Current after dropping ethanol

Next, Ethanol of 3ml was dropped on the film with the pre-processing of AC voltage. The current is shown in Fig. 4. , the current is maintained at the almost constant after it decreased by the drop of ethanol. For the film with DC processing , it did not flow. It is necessary to examine the details,

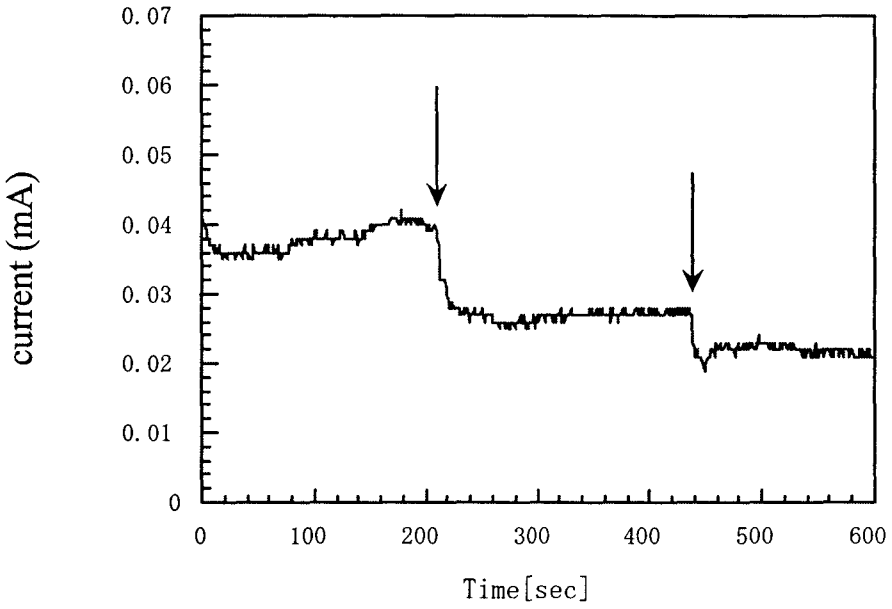

Figure 4. Current at dropping the droplet of ethanol

because the current value depends on pre-processing time and voltage, and the gel condition that depends on the polymerization conditions.

It is possible to add the learning effect on the path of the network conducting polymer by using the property of gel.

References

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